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AUTHOR Sher, Lawrence; Wilkinson, Patricia
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ABSTRACT

The Mathematics Department at Borough of Manhattan Community College (BMCC) (New York) has been actively involved since 1988 in a serious and successful program to improve instruction, understanding, and retention for women and minority students in calculus courses. One result of this work has been students creating calculus animations using computers. This paper reports on a workshop that had participants create projects and animations on the TI-92 calculator. The two projects presented here are an economics project that can effectively exploit the classroom use of the new TI-92 calculator and an animation of the MacLaurin series for Sin(x). Steps to create animations using the TI-92 are also included. (JRH)

Abstract
Workshop presented at Waves *of Change,* AMATYC Twenty-Second Annual Conference, Long Beach, California, Nov. 14, 1996.

The Mathematics Department at Borough of Manhattan Community College (BMCC) has been actively involved since 1988 in a serious and successful program to improve instruction, understanding and retention for women and minority students in our calculus courses. One result of this work has been having our students create calculus animations using computers. This workshop had participants create projects and animations on the TI-92 calculator. Two projects were:

An economics project that can effectively exploit the classroom use of the new TI-92 calculator, the rule of 70. The well known rule of thumb in finance, "*if the principal is kept at a constant rate of compound interest, this amount will double when the yearly percent interest rate multiplied by the number of years equals seventy .*"

An animation of the MacLaurin series for Sin(x).

Student Created Calculus Movies Using Computers and the TI-92

Lawrence Sher
Patricia Wilkinson
Professors of Mathematics
Borough of Manhattan Community College
199 Chambers Street
New York, N.Y. 10007

Workshop presented at Waves *of Change,* AMATYC Twenty-Second Annual Conference, Long Beach, California, Nov. 14, 1996.

The Mathematics Department at Borough of Manhattan Community College (BMCC) has been actively involved since 1988 in a serious and successful program to improve instruction, understanding and retention for women and minority students in our calculus courses. One result of this work has been having our students create calculus animations using computers. **Our project, "Student Created Computer Calculus Movies," finished in first place in the National Council of Instructional Administrators transfer competition, Student *Success Strategies, Applying Technology to Teaching and Learning*, at the American Association of Community Colleges conference at Minneapolis in April, 1995.** One of our students, Donald Stennett, made a presentation at the 4th Annual National Science Foundation-Alliance for Minority Participation Student Research Conference, conference, "Education and Research: Parallel Paths to Excellence", in Tallahassee, Florida, on July 22, 1996. He won **First Place** for his Poster, Animation of Taylor Series of Trigonometric Functions. A major part of his presentation was showing his animations on the TI-92 calculator.

- **Typical Project Using the TI-92**

One economics project that can effectively exploit the classroom use of the new TI-92 calculator is the rule of 70. The well known rule of thumb in finance, "*if the principal is kept at a constant rate of compound interest. this amount will double when the yearly percent interest rate multiplied by the number of years equals seventy*." Therefore, an investment compounded at 7% per year doubles in 10 years, while an investment at 10% doubles in only seven years. Students can by using a TI-92 calculator discover under what conditions this is true. They can also find a rule for tripling their money and generalize it for any multiple. The key to this result is finding the interest rate that will double your money in **x** years. Using the definition of compound interest, the amount a principal, **P**, amounts to in **x** years is $\mathbf{P(1+r)^x}$. **r** is the interest rate expressed as a decimal. When the principal doubles:

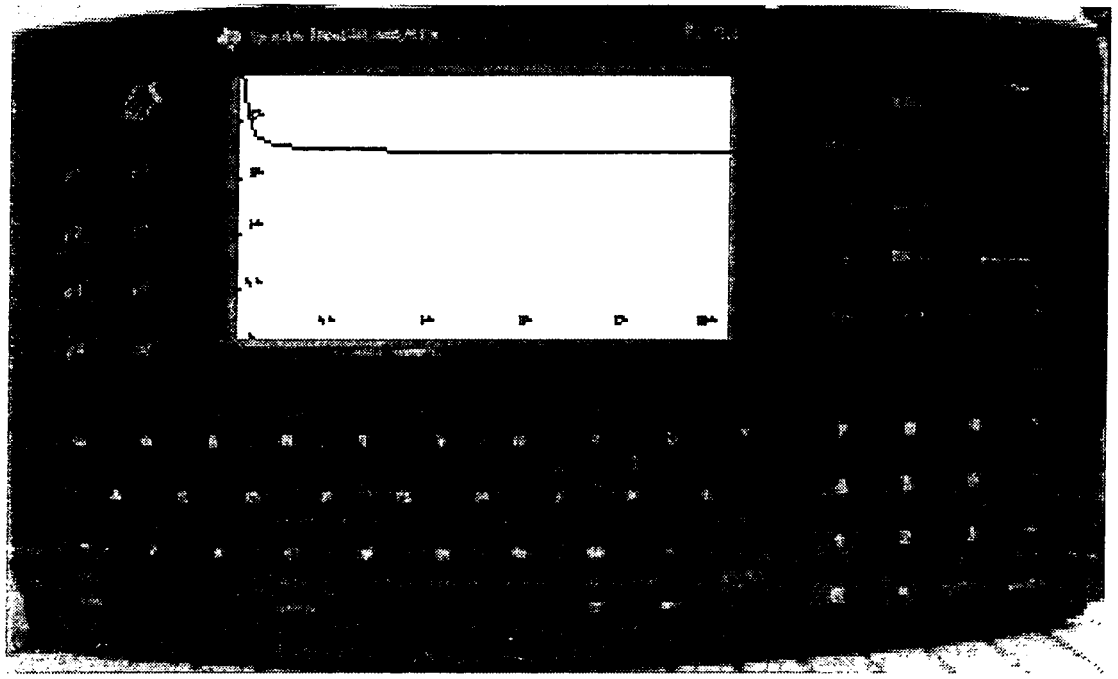
$$\mathbf{P(1+r)^x = 2P, \ Thus \ (1+r)^x = 2}$$

We can use the **solve** command on the TI-92 to find:

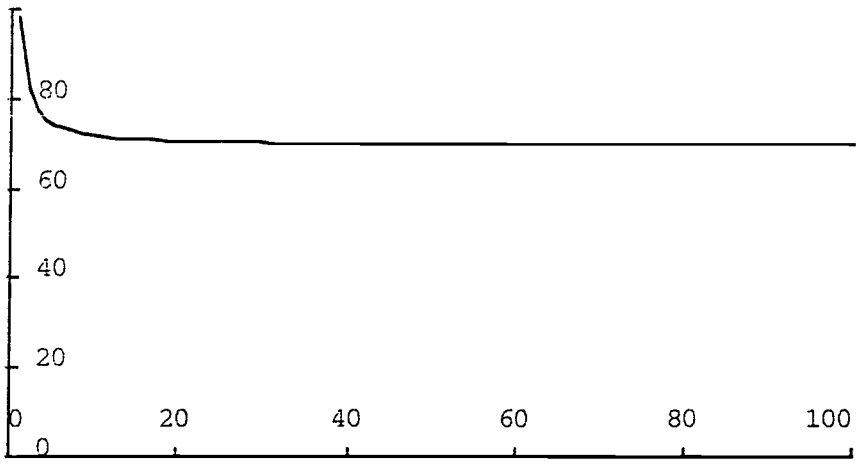
$$\mathbf{r = 2^{1/x} - 1}$$

This rate expressed as a percentage is $100(2^{\frac{1}{x}} - 1)$. When this percent is multiplied by the number of years, the students can graph the function $100(2^{\frac{1}{x}} - 1)x$ on the TI-92 and see where the result is indeed seventy.

The TI-92 Calculator



Detail of TI-92 Screen



The Function is $100(2^{\frac{1}{x}} - 1)x$

The students see the graph seems to have a horizontal asymptote near 70, but is it really an asymptote or does it eventually drop to zero or negative infinity only slowly? The TI-92 includes the computer algebra system *Derive*. Using the **limit** function, the students can see the limit of the $100(2^{\frac{1}{x}} - 1)x$ as x approaches infinity is 100 ln(2) or 69.31.... Thus 70 is a good estimate for large values of x. They can also see that the values of the curve are not as close to seventy for smaller values of x. The reason some financiers call this the rule of 72 becomes evident. Students can use the same process to find $100(3^{\frac{1}{x}} - 1)x$ is the function for tripling their money, and where 100 ln(3) is a good rule for tripling your money, and 100 ln(a) for multiplying your money by a.

- **Animated Movies**

In an exciting state-of-the-art use of computers, our students have started producing animated movies as part of their assessment in Calculus. Software, e.g., *Macromind Director* as well as *Mathematica*, *Maple* , and now the TI-92 allows students to animate their sets of graphs to produce mathematics movies. For example, the student animation of Taylor series showed some interesting mathematical principles. The MacLaurin series approximation: $\sin(x) = x - x^3/3! + x^5/5! - x^7/7! + \ldots$ was shown by starting with the graphs of $y = \sin(x)$ and $y = x$ on the same axes.
The next frame of the animation was $y = \sin(x)$ and $y = x - x^3/3!$
The third frame contained $y = \sin(x)$ and $y = x - x^3/3! + x^5/5!$, etc.

When the frames were shown consecutively, the polynomial appeared to approach the trigonometric function as we increased the number of terms of polynomial.

An interesting effect however occurred at the ends of the graph. As the number of terms increased, the polynomial graph alternated above and below the sine function. The effect was that of wagging tails. For the polynomial expansion of e^x, the tail wagged on the left sided only.

The problem of the wagging tails is new mathematics that was created only through this technology.

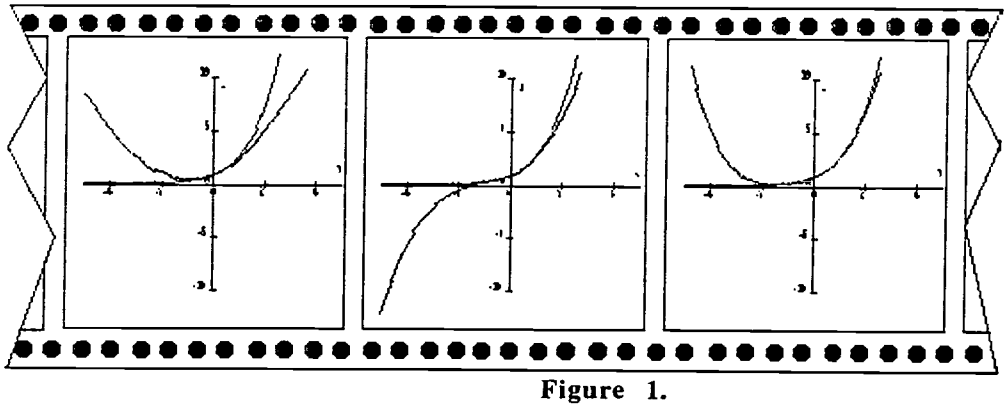


Figure 1.
Animation of MacLaurin Series of e^x
The tail wags on the left side only.

- **Animating Using the TI-92**

You animate on the TI-92 using the following steps:

1) Make the graph that will be the first frame. The graph **mode** may be cartesian, parametric or polar.

2) Use the **Save Copy As** command under F1 to save the graph.

Set the *type* to picture.

Set the *folder* to main.

Set the *variable* to a letter followed the number 1.

Hit **enter** twice.

3) Make the graph that will be the second frame.

4) Use the **Save Copy As** command under F1 to save the graph.

Set the *type* to picture.

Set the *folder* to main.

Set the *variable* to the letter followed the number 2.

Hit **enter** twice.

5) Use the same process until you complete all the frames of the animation.

6) To create the animation, you use the **CyclePic** command.

After **CyclePic** put the letter in quotation marks, (i.e. **CyclePic"e"**).

Next place a comma, and the number of total frames in the animation, (i.e. **CyclePic"e",5**).

Next place a comma, and the length of time in seconds each frame should last in the animation, (i.e. **CyclePic"e",5,.4**).

Next place a comma, and the number of times the animation should show, (i.e. **CyclePic"e",5,.4,3**).

Hit **enter** and the animation will show three times.

Ten BMCC minority students have received $2000 NSF Alliance for Minority Participation research fellowships in mathematics during the past year. Nine of these projects resulted from our calculus movies.

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Signature: Patricia Wilkinson, Lawrence Sher

Printed Name/Position/Title: PATRICIA WILKINSON, PROFESSOR
LAWRENCE SHER, PROFESSOR

Organization/Address: BOROUGH OF MANHATTAN C.C.
199 CHAMBERS ST.
NY, NY 10007

Telephone: (212) 346-8530

FAX: (212) 346-8550

E-Mail Address:

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